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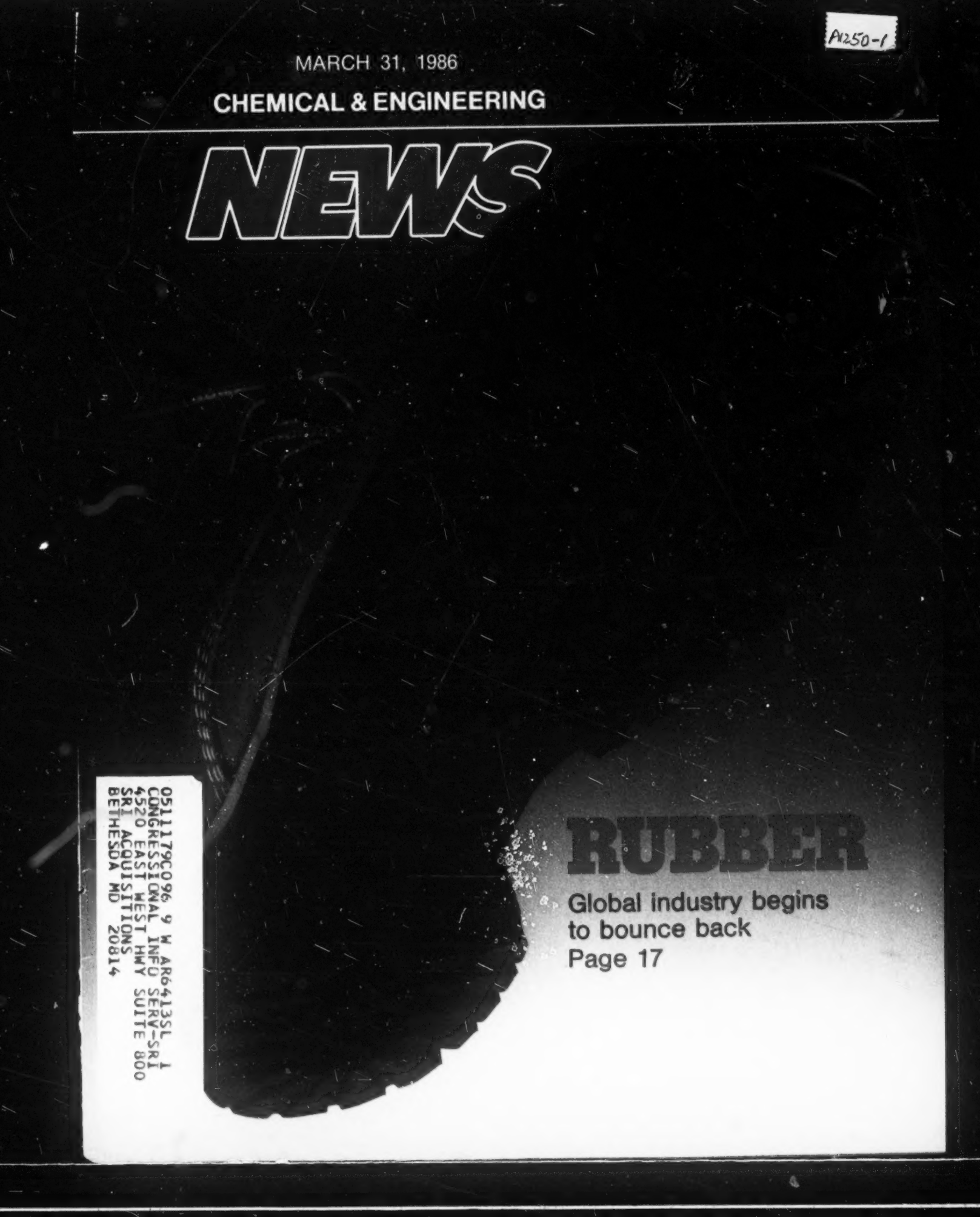
MARCH 31, 1986

CHEMICAL & ENGINEERING

NEWS



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RUBBER

Global industry begins to bounce back

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CHEMICAL & ENGINEERING
NEWS
Volume 64, Number 13
CENEAR 64 (13) 1-60
ISSN 0009-2347
MARCH 31, 1986

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Cover: Shoe soles provide thriving market for rubber reinforced with silica and silicate pigments. Photo courtesy of Degussa

Product Report

The shakeout of the worldwide rubber industry that occurred when oil prices shot up in the 1970s has left a leaner, trimmer industry enjoying higher production and rising consumption. **Page 17**

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Chemical Firms Continue To Ride Stock Market Surge

Performance of C&EN's chemical stock index outstripped Dow Jones Industrials Average over the past 52 weeks

David Webber, C&EN New York

The Dow Jones Industrials Average, the bellwether stock market index, has set so many records during the past year and a half, it was no surprise to many that it surpassed yet another milestone last Thursday when it reached 1804.24. From a year earlier, when the average stood at 1267.45, the Dow Jones Industrials measurement jumped a remarkable 42%, but that increase still fell far short of the 73% surge registered over the same period by C&EN's chemical stock index, which climbed to 377 last Thursday from 223 at the same time a year ago.

C&EN's chemical stock index is based on the performance of the common stock of American Cyanamid, Celanese, Dow Chemical, W. R. Grace, Hercules, Monsanto, and Union Carbide, but the increase was even more widespread. Of the 15 largest chemical companies in terms of sales, the per-share price of 14 firms rose by a double-digit percentage. Only one company, International Minerals & Chemical, registered a decline in the price of its common stock, down 15% over the 52-week period.

Shares of many of the 15 largest chemical companies were selling at the close of trading on March 20 at or near their 52-week high-water marks. Air Products stock, for example, which has become the darling of many investment analysts of late, reached a 52-week high of $81¼ last week, up 67% from its year-earlier level. Also notching 52-week highs were shares of Dow Chemical, up 83% for the one-year period to $52⅞, and Monsanto, up 52% for the same period to $65⅛.

Other companies trading near the top of their 52-week ranges were American Cyanamid, up 37% from a year before to $70⅛; Celanese, another Wall Street favorite, up 121% to $198½; Hercules, up 42% to $45⅞; National Distillers & Chemicals, up 37% to $40½; Olin, up 28% to $40; PPG, up 71% to $64½; and Rohm & Haas, also up 71% to $105½.

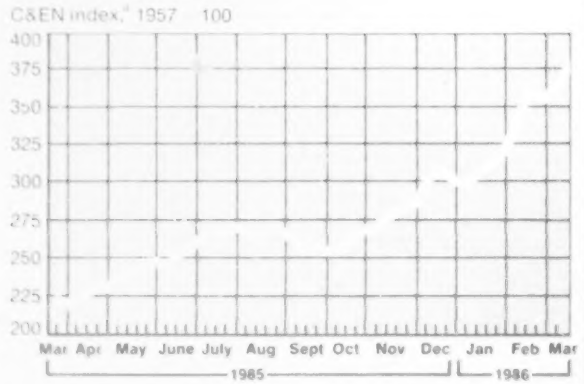
Union Carbide common stock split three-for-one at the beginning of March and closed last Thursday at $19⅞, slightly below its high since the split of $20 per share. The company also distributed to shareholders rights on a one-for-one presplit basis pegged to the value of Carbide's consumer products division, which the company intends to sell as soon as possible. Those rights have been trading separately on the New York Stock Exchange.

To calculate the stock's performance over the past year—a period during which the stock first started to recover from its post-Bhopal nadir and then took a ride on the rocket powered by GAF's abortive takeover attempt last fall—it is necessary to add the market value of

Major stock indexes have lagged the performance of chemicals

	March 20, 1986	March 22, 1985	% change
Dow Jones Industrials Average	1804.24	1267.45	42.4%
New York Stock Exchange Composite	136.13	103.65	31.3
New York Stock Exchange Industrials	155.76	119.09	30.8
American Stock Exchange Index	267.32	224.99	18.8
Over-the-Counter Composite	372.71	278.91	33.6
Over-the-Counter Industrials	372.97	297.63	25.3
Standard & Poor's 500	236.54	179.04	32.1
Standard & Poor's 400 Industrials	261.61	199.73	31.0
C&EN's chemical stock index	377	223	72.9

Chemical stocks gained 52% over the past 12 months



[a] C&EN weighted stock price index of American Cyanamid, Celanese, Dow Chemical, W. R. Grace, Hercules, Monsanto, and Union Carbide

the rights back into the market value of the common stock. On that basis, Carbide's market value (the product of the number of shares of common stock times the stock price plus the product of the number of rights times their price) amounted last Thursday to $6.78 billion, up 157% from the year-earlier market value of $2.64 billion. At that time, the per-share price of Carbide's common stock stood at $37⅞.

On that basis, Carbide's stock performance, once adjusted for comparability to a year ago, has been the best of any of the 15 largest chemical companies over the past 52 weeks. Even if the value of the rights is excluded, the price of a share of common stock, when adjusted for the three-for-one stock split, rose 56% over the 52-week span.

The rapid rise of C&EN's chemical stock index outpaced all the major stock market indexes. Chemical stock values rose more than twice as much during the same period as the New York Stock Exchange Composite index, up 31% to 136.13; the New York Stock Exchange Industrials index, also up 31% to 155.76; the Over-the-Counter Composite index, up 34% to 372.71; the Standard & Poor's 500 index, up 32% to 236.54; and the Standard & Poor's 400 Industrials index, which rose 31% to 261.61.

C&EN's chemical stock index rose nearly three times as much as the Over-the-Counter Industrials index, which climbed 25% during the 52-week period to 372.97, and nearly four times as much as the American Stock Exchange Index, which increased 19% between March 22, 1985, and March 20, 1986, to 267.32.

Some of the chemical stock index's exceptional growth over the past year is due to extraordinary circumstances. Part of the reason Carbide stock is so much higher on a percentage basis, for instance, is that it started the 52-week period near its post-Bhopal low. Carbide common stock closed the Friday before the Dec. 3, 1984, gas-leak disaster in Bhopal, India, at $48⅞. After the disaster, the per-share price dropped into the mid-30s, where it was languishing in March. The stock climbed back to slightly above the pre-Bhopal plateau during the summer, after which first rumors of and then an overt takeover bid by GAF brought the stock value up to $75 at the turn of the year.

Many chemical stocks are trading near their 52-week high

Company	Latest price[a]	% change from a year ago	52-week range High	52-week range Low	Dividend yield[b]
Air Products	$ 81¼	67%	$ 81¼	$46⅞	1.8%
American Cyanamid	70⅛	37	72½	48	2.7
Celanese	198½	121	200	88⅛	2.4
Chesebrough-Pond's	43½	35	48½	31	4.6
Dow Chemical	52⅞	83	52⅞	28	3.4
W. R. Grace	51	25	57¼	35½	5.5
Hercules	45⅞	42	47⅜	31½	3.5
International Minerals	34⅞	−15	44	29¾	2.9
Monsanto	65⅛	52	65⅛	40⅝	3.8
Morton Thiokol	35⅞	22	40½	28⅝	2.0
National Distillers	40½	37	41½	26⅜	5.4
Olin	40	28	41¾	29⅛	3.8
PPG Industries	64½	71	65¼	34½	2.7
Rohm & Haas	105½	71	106	55¾	2.1
Union Carbide[c]	19⅜	56	20	7⅛	5.8

a As of close on Thursday, March 20, 1986. b Annual dividend as % of stock price. c Adjusted for 3-for-1 stock split and excluding market value of rights distribution.

Nonetheless, most chemical stocks have performed superbly over the past 52 weeks. Wall Street analysts, however, present a mixed forecast for the group during the coming months. Overall, they foresee a generally positive environment for the chemical industry for the remainder of 1986 because of such economic factors as declining interest rates and the falling value of the U.S. dollar, which means that foreign earnings will translate at higher levels and probably will mean that the depredations of imports in the U.S. market for commodity chemicals will be eased somewhat. Analysts also believe that chemical industry performance will be aided by trends such as the steady shrinking of commodity chemical capacity both in the U.S. and in Western Europe and by declining prices for raw materials and energy.

On the other hand, Wall Street continues to worry about the stalled agricultural economy, which has had severe effects on the earnings performance of many chemical companies in recent quarters.

Behind IMC's stock price decline—the only company in the group of 15 largest chemical firms whose stock price fell during the past 52 weeks—was the agricultural slump, which has meant poor sales and prices for IMC's fertilizer products and thus poor earnings. In the fourth quarter of 1985, for instance, IMC net income declined 90% from a year earlier. Total 1985 net income of $55.2 million was 47% lower than in 1984. Nor is there any sign that performance will improve this year. In mid-February, the company lowered its earnings estimate for the fiscal year ending June 30 to somewhere in the range of 50 cents to 75 cents per share, down from the $1.00 per share forecast issued just two months earlier. Just two months before that, IMC had predicted that fiscal 1986 earnings would decline to about $2.50 per share. In the fiscal year that ended June 30, 1985, IMC earned $4.39 per share. In light of this tremendous darkening of the earnings outlook, IMC last month also slashed its quarterly dividend to 25 cents per share from 65 cents per share. □

Global Rubber Industry Resumes Growth Trend

Bruce F. Greek, C&EN Houston

After years of just plodding along, rubber producers throughout the world—and especially those in the U.S.—may well have something going for them. But the medicine has been bitter.

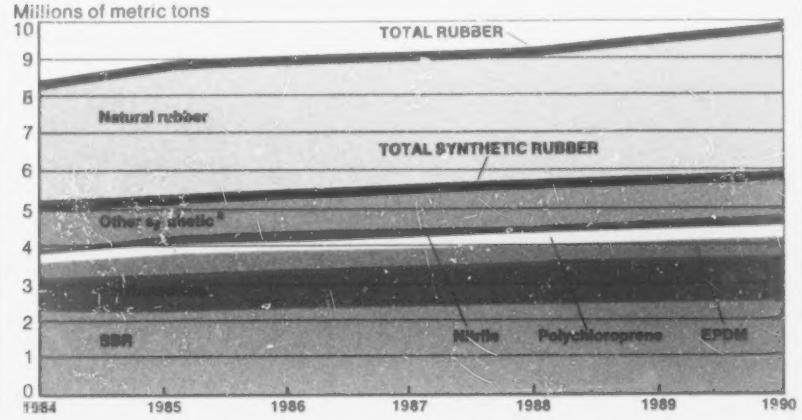
The oil shocks of the mid- and late 1970s sent many rubber producers into a tailspin. The rising costs of energy and feedstocks, coupled with the downsizing of automobiles and thus automobile tires and other automotive parts, conspired to limit producers' growth prospects, and when profits did materialize in the industry, they were minimal. As a result, producers of elastomers were forced to review operations, cut costs, and close down marginal plants. The resulting shakeout has left the rubber industry in perhaps a better position than at anytime in the past decade.

It remains to be seen, of course, whether producers will take advantage of their leaner operations, lower feedstock costs from falling oil prices, and a resurgent production situation.

After declining in recent years, production and consumption of rubber are rising again, at least in noncommunist countries, for which figures are compiled regularly. Combined consumption of new rubber in those countries this year is expected to exceed 9 million metric tons, according to the International Institute of Synthetic Rubber Producers (IISRP), using data compiled by its members, and the International Rubber Study Group. Production will follow consumption closely, with inventory building expected to be minor.

Of the total consumption of new rubber (elastomers) in 1986, a little more than 60% will be synthetic. The remainder supplied by natural

Demand to grow slowly for rest of decade



Note: For noncommunist countries only; carboxylated latex excluded. a Includes SBR latex, butyl, polyisoprene, and miscellaneous. **Source:** International Institute of Synthetic Rubber Producers

rubber will be up again slightly this year but appears to be leveling off.

Another 4.1 million metric tons of new rubber will be consumed by the various communist countries of Eastern Europe, China, and Asia. More than 78% of this consumption will be synthetic rubber, IISRP estimates. Only in the China/Asia countries will natural rubber dominate with more than 61% of an estimated 750,000 metric tons of consumption.

Because synthetic rubber is a larger proportion of the total rubber consumed in communist countries than in noncommunist countries, worldwide consumption of rubber will be nearly 66% synthetic in 1986. That's about the same as in 1985 but down slightly from 1984. In the long run, little change is expected in the pattern of world consumption, because synthetic's share in communist countries will hold at about 78%.

In noncommunist countries so far in the 1980s, natural rubber, ethylene-propylene-diene monomer (EPDM), and several smaller-volume synthetic rubbers have made inroads in relative share of total consumption largely at the expense of styrene-butadiene rubber (SBR). Other big-volume synthetic rubbers, such as polybutadiene (solution type), polychloroprene, nitrile, and butyl, have held onto their shares of the market.

As perhaps might be expected of the oldest large-volume synthetic rubber, the demand for SBR is cyclical. For the rest of the 1980s, it is expected to be on the upward part of the cycle. According to IISRP data, as recently as 1979, total demand for SBR as solid and latex reached 3.4 million metric tons in noncommunist countries. Demand dropped to about 2.4 million metric tons in 1985, however. If the subsequent slow recovery continues, 1990 demand will be slightly more than 2.6 million tons, IISRP believes.

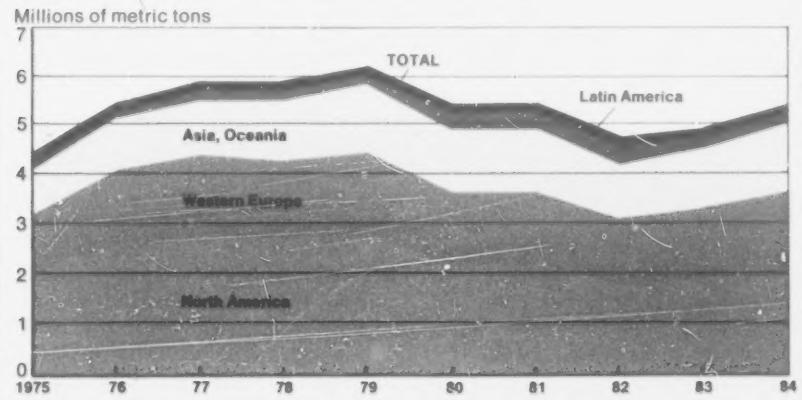
In noncommunist countries, capacity to make SBR far exceeds demand, an unfortunate fact equally true for some of the other synthetic rubbers. SBR capacity in 1985 was some 5.15 million metric tons, according to IISRP estimates. Plants, therefore, operated at an average rate of barely over 50% of capacity. At present, some capacity may be in a shut-down, inoperable state, but not yet officially scrapped.

By keeping its consumption ahead of that of natural rubber, SBR maintains its title of workhorse of the rubber industry in North America. But SBR's position is threatened by the increasingly severe service requirements that fabricated rubber products are now expected to meet. Many of SBR's physical properties are poorer than those of natural rubber and of other synthetic rubbers, particularly specialty rubbers with developed niches and use patterns. However, compared with the widely fluctuating prices of natural rubber, the price of SBR is relatively low and quite stable. This gives SBR a very strong economic advantage. Therefore, on a cost-performance basis, SBR will get the nod more often than not.

During 1985, however, U.S. SBR producers faced difficulties as production declined 16% to 804,840 metric tons, according to the Rubber Manufacturers Association (RMA). That amount was not much more than half the 1.54 million metric tons produced in the U.S. in 1973.

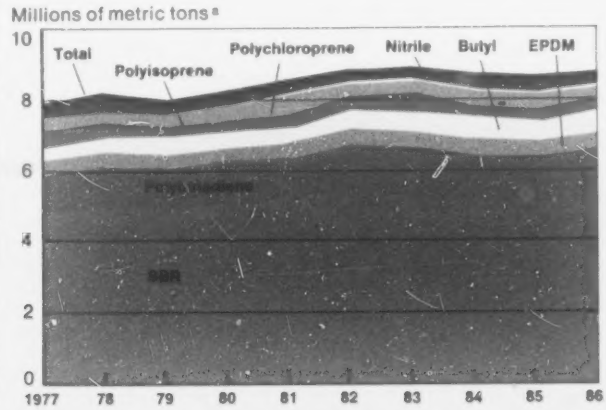
During the past two years, U.S. SBR capacity has held steady at about 1.04 million metric tons, with a small amount of that capacity shut

Synthetic rubber production in noncommunist countries continues moderate recovery

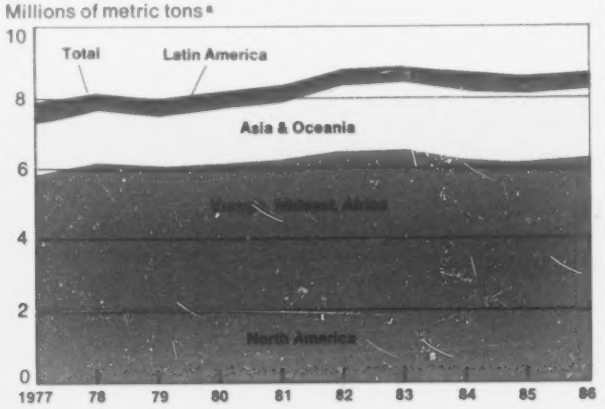


Note: South Africa production included in Asia, Oceania segment for 1975–79; in Latin America segment 1980–82; and in North America segment 1983–84. **Source:** International Institute of Synthetic Rubber Producers

Synthetic rubber capacity peaked in 1983 . . .



. . . declining in North America but growing in some other areas



[a] Noncommunist countries only; excludes specialty rubbers but includes carboxylic latex. **Source:** International Institute of Synthetic Rubber Producers

down in 1985. The operating rate of U.S. plants in 1985 was about 81% of nameplate capacity. That relatively high operating rate results from a series of shutdowns and scrappage of some plants during the early 1980s that removed about a third of capacity. If forecasts for very slow growth for SBR during the rest of this decade are accurate, and if no additional SBR capacity is shut down, producers can expect the operating rate to increase only modestly for some time.

Tires and tire components such as tread rubber consume more than 70% of SBR produced in the U.S. The share of consumption going into tires and components has been rising since the late 1970s—even though consumption of SBR in tires dropped about a third. Unfortunately, the amount of SBR consumed by nontire uses has declined even faster, dropping by more than half during the same period. The reduction in the amount of SBR used in tires stems from changes in the size and type of tires—largely a shift to radials—sold in recent years. The decline in demand in nontire uses results from the need for elastomers that meet tighter specifications.

The decline in SBR's use in tires and tire components could be slowing and may end by the early 1990s. Depending on the way crude oil prices go during the rest of the 1980s, the shift to smaller, lighter cars, either produced domestically or imported, and the shift to longer-lived radial tires for all kinds of passenger cars could slow drastically. However, changes started years ago have some momentum and could continue. During the rest of this decade, industry sources forecast that the share of sales held by small cars likely will remain the same or even increase marginally. Because of competition and consumer demand, sales of bias-ply and bias-belted tires also will remain high.

Some further shift toward radial truck tires will continue, but this shift is forecast to have only a minor impact on SBR. Rising imports of tires could force a continuing decrease in U.S. passenger tire production and accelerate the decline in U.S. SBR consumption. Tire exports from the U.S., which already are small, are continuing to shrink, further eroding U.S. consumption of SBR.

These factors affecting SBR consumption have been at work for more than a decade. They have had a direct impact on tire production, causing a decline in production of most kinds of tires and causing tire-making plants to be closed. Tire mileages, which increased 100% or more during the decade, influenced this decline most. However, radial tires reduce SBR demand still further because less SBR is used in radials than in the earlier bias-ply and bias-belted tires. Radial tire sidewalls have a much higher natural rubber content because of a need for properties such as resilience, aging stability, and building tack (adhesiveness needed to keep the various parts of a tire together during its assembly). Use of SBR in tire treads—usually blended with polybutadiene to increase abrasion resistance and add to tire life—has not changed much. The percentage of SBR and other synthetic rubbers has declined to betweeen 60 and 65% in radial tires from more than 85% in older-style tires. Moreover, smaller tire sizes, on average, have reduced the amount of new rubber going into tires and tire components.

Owing to their size, truck tires, though produced in much smaller numbers, require large amounts of rubber. Historically, heavy-duty truck tires have contained larger fractions of natural rubber than are used in passenger and light-truck tires, because they require high resistance to heat and wear under heavy loads. Radial heavy-duty truck and bus tires account for about a third of total truck tire production, whereas radial passenger car tires are three quarters or more of automobile tire production. According to forecasts, the shift to a higher percentage of radial truck tires will occur more slowly than it has for passenger car tires and will affect SBR consumption more slowly as well.

Many other kinds of tires, for uses ranging from aircraft to utility trailers, require a wide variety of rubber compositions. The quantities of such tires produced are small, and

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total new rubber consumed in them also is small. Even with a resurgence in demand for huge tires for earth-moving equipment as road building and repair increase, changes in miscellaneous tire production will not have a large effect on demand for rubber and for SBR.

The nontire uses of solid and latex forms of SBR are dominated by automotive uses, mechanical goods, and carpet backing. All of these markets have declined because of higher performance requirements for the fabricated forms. The decline has slowed, however, if for no other reason than that the base has become small. The cost/performance factor remains important to use of SBR, helping it to compete against other rubbers that perform better but cost much more.

In the U.S., solution-polymerized *cis*-1,4-polybutadiene takes second place to SBR in share of synthetic rubber consumption. Apparent 1985 consumption was 374,200 metric tons, according to RMA figures, down 9% from 1984. Production in 1985 was down more than 8% to 329,450 metric tons. A modest 7% increase in imports accounted for the rest of the supply. Imports, at nearly 70,000 tons last year, have continued to increase significantly during the 1980s.

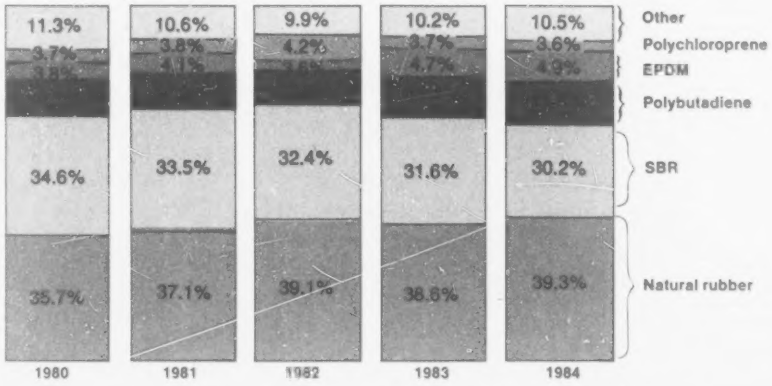
Capacity to make polybutadiene in the U.S. totals about 425,000 metric tons and has not changed much during the past two years. The operating rate of polybutadiene plants last year was about 78%. Other than debottlenecking, no capacity additions for polybutadiene are forecast for this year or next. Operating rates could increase this year and later on. The decline in crude oil prices would tend to favor use of heavier feedstocks such as gas oils in steam crackers that make olefins, thereby raising butadiene production and probably significantly lowering its cost to polymer producers. Lower-cost polybutadiene produced in the U.S. could slow imports and slightly shift consumption away from natural rubber.

Worldwide, tires and tire products consume more than 77% of the total polybutadiene output, whereas they consume smaller percentages of other kinds of rubber, according to IISRP data. In North America, more than 80% is used in tires. In the past, the tire uses accounted for an even higher fraction, but slower growth in tires than in high-impact polystyrene and mechanical goods has cut into the tire share.

Polybutadiene's major tire use is in treads, for which it provides long wear and less resistance to rolling than most lower-cost elastomers. Its major drawback is its poor wet-skid performance. As a result, polybutadiene is blended with SBR and natural rubber in varying amounts, depending on the kind of tire being made. Passenger car tire treads generally are blends of polybutadiene and SBR, whereas truck and bus tire treads are blends of polybutadiene and natural rubber.

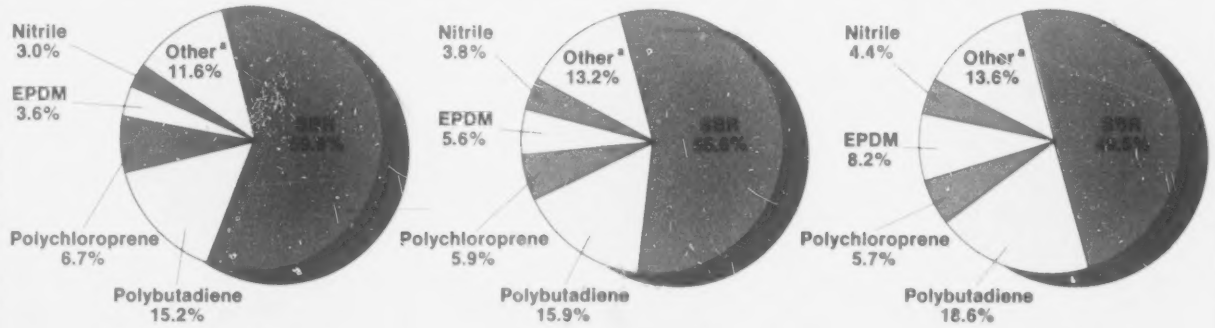
The outlook for growth of polybutadiene in tires will follow that

Natural rubber use increased in early 1980s

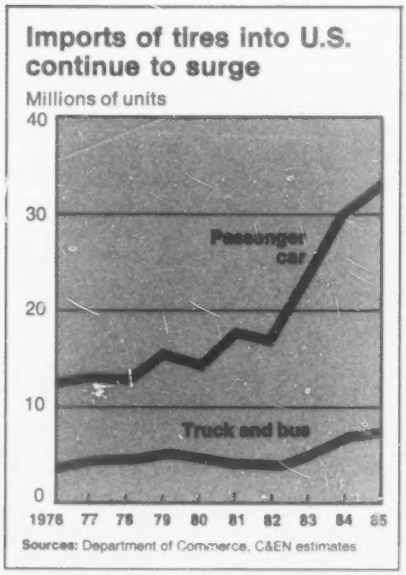


[a] For noncommunist countries only. **Source:** International Institute of Synthetic Rubber Producers

Smaller-volume specialty rubbers gain share of total world production at expense of SBR



Note: Noncommunist countries only. [a] Includes polyisoprene, butyl, and all others such as specialties; latices included with individual rubbers.
Source: International Institute of Synthetic Rubber Producers



for tire demand. No significant changes are expected in the composition of polybutadiene blends. Increased production of radial tires also will have little effect on demand for polybutadiene in tires. Declines in the value of the dollar, which may reduce finished tire imports, probably have more influence than other factors over polybutadiene demand in tires.

Rubber-modified polystyrene and use in mechanical goods account for the remainder of polybutadiene consumption. Addition of polybutadiene and some other elastomers to polystyrene improves impact resistance of the final resins. Higher percentages of polybutadiene, as much as 10% of the total resin, increase impact resistance. These resins are used largely in various consumer and recreational products. Consequently, growth in demand for polybutadiene as a modifier of polystyrenes will depend on growth of these consumer products. This growth is cyclical because it is influenced by fashion, but likely will average 5% annually over the rest of the 1980s.

Mechanical goods require relatively small quantities of polybutadiene. Demand growth for polybutadiene for such items is forecast to be more than for that in tires, but less than that for modifying polystyrene. Longer term, this use will have little effect on consumption.

Other elastomers—such as emulsion-polymerized cis-1,4- material, the trans-1,4- form, and various widely modified polymers—are made of butadiene. Both production and consumption of such rubbers are small. End uses are specialized, so growth varies but will not make those rubbers large-volume materials before the 1990s.

Ethylene-propylene (EP) elastomers have become the third-largest-volume rubber in the U.S. And the elastomers' worldwide production may have surpassed that for butyl rubber. But, because in some countries only one company produces butyl rubber, no figures are available that separate butyl production on a worldwide basis from the "all-other" category. Output of EP rubber in noncommunist countries

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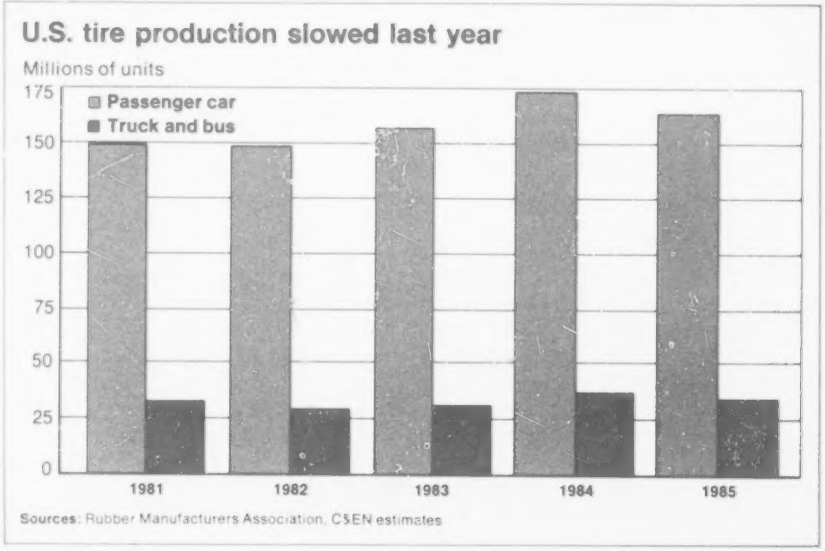
reached 430,000 metric tons in 1984, according to IISRP data. In the U.S., 1985 production was 214,800 metric tons, almost the same as 1984 production, or roughly half the world production, according to RMA. Exports of EP rubber increased more than 14% last year to almost 38,500 tons, one of the few rubbers, and the only large-volume one, to show an increase in exports.

During the past two years, capacity to make EP rubber—both the copolymers and terpolymers (EPDM)—has been rising slowly and totals more than 260,000 metric tons. Some capacity additions, as well as debottlenecking of existing capacity, are under way. These could add as much as 10,000 tons to U.S. total capacity by the beginning of 1987. If 1986 production of EP rubber is 220,000 tons, as some forecast, the existing capacity will be operated at about 85% of nameplate, or possibly slightly less as expansions come on stream.

Historically, production of EP rubber in the U.S. has been cyclical, reaching new peaks during economic expansions and falling significantly during recessions. The causes of these cycles vary. During the early commercial production that began in 1961 but grew slowly until 1964, this rubber was used largely by the automotive industry as a tire rubber and in mechanical goods. Problems in its use during tire manufacture led to declines in this use during the 1970s and to a realization among producers that tires would not become a major use. As a result, producers have worked to improve production processes to lower costs and to improve quality. Also, they have found many new uses for EP rubber, most of which are in consumer durables and subject to economic cycles.

Relatively small amounts of EP rubber now go into tires, and most of that is used in tubes and in the white sidewall stripe for passenger car tires. Other automotive uses trended downward as U.S. car production declined in the early 1980s. Car sizes also declined, causing such parts as hoses, belts, and door seals and other weather stripping to be downsized as well. Competition from other rubbers also keeps up the pressure for possible shifts. Thus, the longer-term growth rate for use of EP rubber in automobiles is predicted to be low.

About 75% of EP rubber goes into nonautomotive uses, the largest five of which are wire and cable coverings, modification of polymers, single-ply roofing, oil additives, and some thermoplastic elastomers. A large miscellaneous group of uses, however, ranks second to automotive uses in the U.S.



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Specialty elastomers have a number of important uses

Specialty elastomers are produced with a wide variety of physical properties. Most are expensive. Many have high growth rates from small bases. Some are produced in tiny volumes. Larger-volume examples include:

Acrylics. These elastomers, most often made of ethyl-, butyl-, or methoxy and ethoxy ethyl acrylates, have good heat and oil resistance. As a result, their major uses are in seals, gaskets, and hoses. They sell at about $2.50 per lb. U.S. annual consumption is less than 10 million lb. Major U.S. producers are American Cyanamid, Du Pont, and B. F. Goodrich Chemical.

Chlorosulfonated polyethylenes. Crystalline polyethylene that is modified by chlorine and sulfonyl groups has toughness; high resistance to ozone and light; and good resistance to oxidation, heat, oil, and corrosive materials. A wide variation in compounding and curing allows use as wire and cable coverings, roofing, automotive parts, pond liners, hoses, and belting. Most types of this elastomer sell for less than $2.00 per lb. Consumption this year may reach 60 million lb. Du Pont is the major U.S. producer.

Copolyester ethers. Polymers in this group result from condensation of polybutylene terephthalates and polytetramethylene ether glycol terephthalate. They have high strength, abrasion resistance, good resistance to chemicals and petroleum, and a relatively wide useful temperature range. Some 20 million lb of these elastomers may be used in 1986 as hose, wire and cable coverings, as well as in various automotive parts. Selling prices range from $2.00 to $3.00 per lb. Major U.S. producers are Du Pont, GAF, and General Electric.

Epichlorohydrins. Homo- and copolymers of epichlorohydrin are fabricated into elastomeric products that have low gas permeability, good resistance to petroleum products, and low-temperature flexibility. Most of the 15 million lb consumed in the U.S. will go into automotive products such as gaskets, hoses, and motor mounts. Selling prices are more than $2.00 per lb. B. F. Goodrich Chemical and Hercules are the major U.S. producers.

Fluorinated polymers. Fluorine-containing polymers, made of C_2 and C_3 fluoro-olefins, have good resistance to heat, chemicals, and weathering, and good mechanical properties. About 5 million lb of these expensive elastomers, which can sell for more than $15 a lb, will go to severe-service uses as seals, gaskets, hoses, and other items in automotive, oil-well drilling, and other industries. Sizable producers are Du Pont, Ethyl, and 3M.

Polysulfides. Oldest of the specialty elastomers, these materials have good resistance to ozone, oxygen, sunlight, and swelling caused by chemicals. They have low permeability to gases and liquids, and good low-temperature properties. About 20 million lb are expected to be consumed in 1986, largely as sealants. Prices are about $2.00 per lb. Morton Thiokol is the major U.S. producer.

Silicones. With a backbone of silicon and oxygen, these elastomers are known for their resistance to ozone, weathering, and hydrocarbons. Various side groups added to the chain can give other properties. Most of the approximately 75 million lb expected to be consumed in 1986 will go into sealants and adhesives, with smaller quantities used in automotive parts, wire and cable coverings, and medical equipment. Prices range higher than $2.50 a lb with very special types for medical uses priced at more than $100 per lb. Major U.S. producers are Dow-Corning and General Electric.

Thermoplastic block copolymers. Most of these rubbers are based on polystyrene and polybutadiene with a wide variety of types available for diverse uses. More than 250 million lb will go into adhesives, coatings, shoe soles, other polymers as modifiers, toys and other consumer products, as well as other fabricated products. Prices range from 50 cents to $2.50 per lb. Shell Chemical is the major U.S. producer.

Urethanes. These elastomers are known for high abrasion resistance and strength. Major uses are in such items as wheels for industrial trucks, seals of various kinds, adhesives, and fibers. Consumption could reach 175 million lb this year. Selling prices range from about $1.00 to $2.00 a lb. Among important U.S. producers are American Cyanamid, Dow Chemical (Upjohn), Du Pont, Mobay, and Uniroyal.

Of all the EP rubber uses, single-ply roofing made mostly of EPDM now gets the most attention because its production grew so fast over the past decade, from practically nothing to about 30,000 metric tons this year. The ozone and weathering resistance of EPDM spurs this use, as do other advantages such as its lighter weight, lower cost of installation (compared with built-up roofs), and its suitability for use over heat-sensitive expanded polystyrene or polyurethane foam insulations. Now, with problems of seam adhesion and flashing components solved, both new and replacement roofing of this elastomer are well established. However, growth in this use of EP rubber—almost all EPDM—will probably slow because of the larger size of the base, reduced industrial building, and competition from some elastomer-modified asphalt or bitumen products.

Use of EP rubber in thermoplastic olefin elastomers has had a high growth rate. These elastomers are blends of the rubber and a polyolefin (most often polypropylene) and are sometimes crosslinked. They go into many nontire automotive items such as exterior body and bumper parts, hoses, gaskets, and dashboard parts. In addition, those elastomers are used in severe-service wire and cable coverings and molded items. Because of several new developments, growth forecasts for olefin elastomers are high—about 10% a year.

The wide range of commercial uses of EP elastomers and their substantial export demand combine to give these rubbers one of the better demand forecasts at this time in the U.S. Because a large fraction is produced in the U.S., world production of the materials also has been cyclical, but has continued to increase at good rates.

Worker taps rubber tree at Goodyear's Dolok Merangir plantation in Sumatra

Other smaller-volume rubbers have not had the swings in production that EP rubber has had, but their production has trended downward. For polyisoprene, polychloroprene, and butyl rubbers, for instance, 1984 world production ranged from levels that barely matched previous production highs to levels well below these. World production of polyisoprene in noncommunist countries totaled 146,000 metric tons in 1984, well below the peak of 242,000 tons in 1979, according to IISRP. Output of nitrile, on the other hand, was 238,000 metric tons in 1984, just barely below its all-time production high of 239,000 tons also in 1979.

The capacity situation for polyisoprene is unusual. Estimates for Eastern Europe, including the U.S.S.R., total about 950,000 metric tons, more than twice the capacity of the rest of the world, which is less than 390,000 tons. Industry sources suggest that in Eastern Europe, polyisoprene capacity and utilization of that capacity are high to minimize dependence on natural rubber supplies. That explanation is consistent with the relatively large fraction of synthetic rubber out of total rubber consumed in communist countries, or more than 78% of the total in 1985, according to IISRP.

Polyisoprene in the cis-1,4- form has properties and chemical structure closer than any other rubber to the widest produced form of natural rubber, *Hevea brasiliensis*. Therefore, it can be used interchangeably with natural rubber in most applications. The trans-1,4- form mirrors two other natural rubbers, gutta blata and gutta percha. All three of these rubbers have properties very different from those of *cis*-1,4-polyisoprene, either natural or synthetic. The trans-1,4 forms- are made in small quantities worldwide and are used in products for which high tensile strength and abrasion resistance are important.

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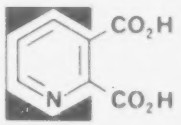

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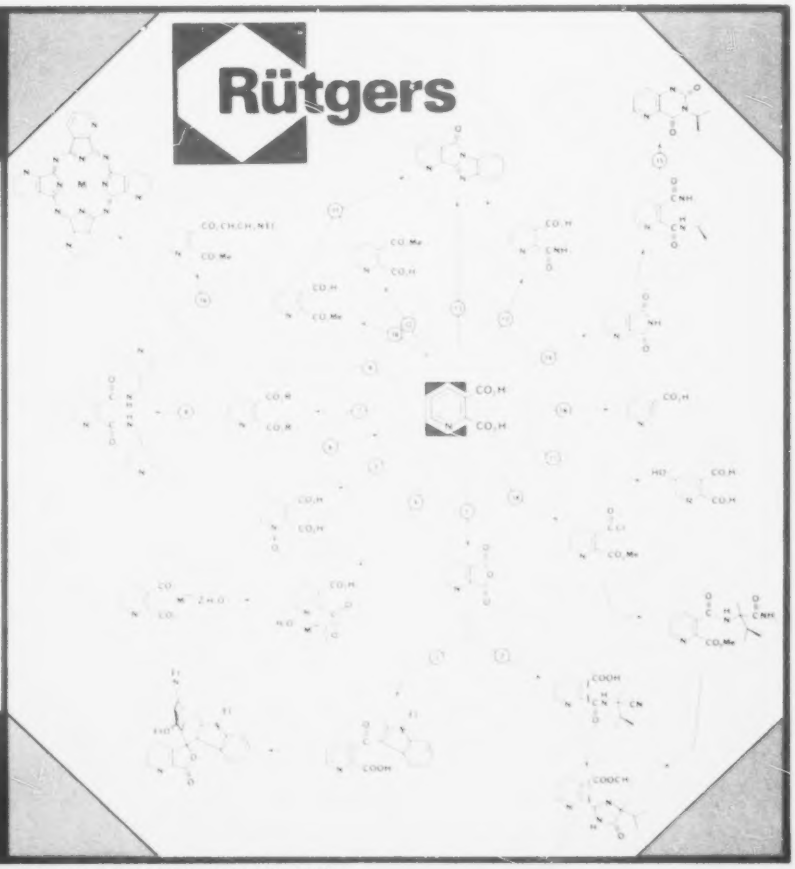
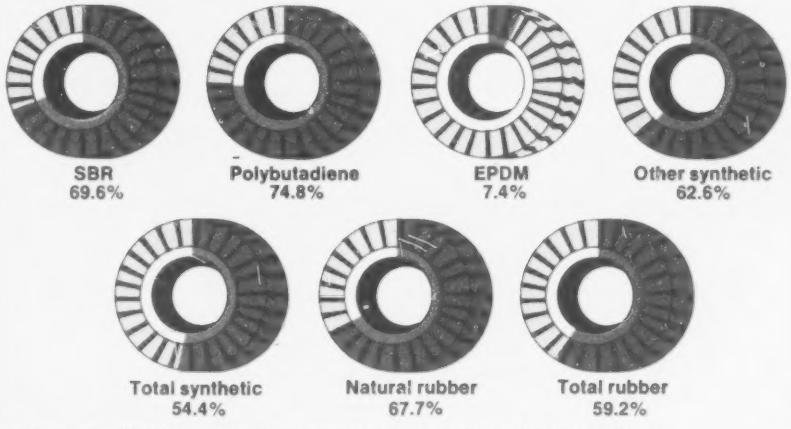


CIRCLE 18 ON READER SERVICE CARD

Tires and tire products take well over half of world's rubber consumption



Note: Noncommunist countries only. Source: International Institute of Synthetic Rubber Producers

U.S. consumption of synthetic *cis*-polyisoprene has fallen to about half the peak annual consumption of more than 100,000 metric tons in the early 1970s. Relatively lower prices for natural rubber and increased raw material costs for making synthetic polyisoprene prompted this decline and reduced the number of U.S. producers to one—Goodyear. Because the cost of direct manufacture is high, supply of the monomer has become limited to that recovered from product streams of catalytic and steam cracking.

Tires consume more than half of polyisoprene output. The amount used in tires is about equally divided between passenger car and truck and bus tires. A much higher fraction of polyisoprene is used in truck tires because of its high resistance to wear and heat buildup under heavy loads. Growth in tire use likely will continue at a slow pace and will depend on the usual factors of cost competition with other rubbers, general demand for tires, size of tires, and the speed of the shift to radial-ply construction for truck and bus tires.

In polyisoprene consumption, various mechanical goods are a distant second to tires. Other uses are in footwear soles, rubber bands and erasers, hoses, consumer and medical products, and sealants. With natural rubber constantly looming as a potential replacement for polyiso-

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prene in all these uses, polyisoprene's growth depends heavily on cost competition, and that depends on monomer cost. If crude oil prices remain much lower than in 1985, more naphtha and gas oil will be cracked for making olefins in steam crackers and fluid catalytic cracking units, thereby raising output of isoprene and lowering its cost.

Polychloroprene production has followed a pattern similar to that of polyisoprene. In 1984, total production in noncommunist countries was about 313,000 metric tons, down less than 12% from production in 1979. U.S. production in 1984 was 130,000 metric tons, down 29% from 1979 production. Two major U.S. producers, Denka Chemical and Du Pont, have a combined capacity of a little less than 170,000 metric tons.

U.S. exports of polychloroprene, down about 5% in 1985, were more than 41,000 metric tons, making exports the largest outlet for U.S. production. Imports totaled more than 2000 metric tons in 1985, leaving apparent consumption at about 90,000 tons. Because prices of polychloroprene are well above $1.00 per lb at producing plants, consumption is limited to those applications for which this rubber will meet the service requirements.

Copolymer Rubber & Chemical Corp. EPDM plant at Addis, La.

Polychloroprene is not a tire rubber. Its major end uses are in mechanical goods for severe service in industry and in autos and trucks. Its high strength and resistance to abrasion, hydrocarbons, and aging contribute to its growth prospects. On the other hand, high cost and difficulties in processing the rubber into fabricated items tend to limit its growth.

Nitrile is another nontire rubber of significant commercial importance. Noncommunist countries produced some 238,000 metric tons of it in 1984, down slightly from the record production of 239,000 metric tons in 1979, according to IISRP. U.S. production in 1985 was down 19% from 1984 to 54,500 metric tons, as reported by RMA. U.S. imports in 1985 dropped slightly to 11,500 metric tons, but exports declined more than 21% to 6700 metric tons, with a net apparent consumption of 60,300 metric tons.

Nitrile is a copolymer of acrylonitrile and butadiene. Its properties are influenced by the composition of the polymer. In general, the higher the acrylonitrile content, the higher the rubber's resistance to hydrocarbons, abrasion, and gas permeation. Rubber with low acrylonitrile content has better low-temperature and resilience properties. Extensive compounding is required to give fabricated nitrile rubber products adequate resistance to ozone

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and oxidants. Major uses include hoses, gaskets, seals, and many other mechanical goods. Because of nitrile rubber's resistance to hydrocarbons over a wide range of temperatures, growth in demand depends heavily on industrial operations and automotive output. Its cost is relatively high at more than $1.00 per lb, which tends to limit growth. Competition is strong from other elastomers that can withstand severe service.

Because of its impermeability to air, butyl rubber, another of the smaller-volume elastomers, is used mainly in tires. No data are available on worldwide or U.S. production of butyl rubber because there are so few producers. C&EN estimates that noncommunist countries produced 400,000 metric tons of butyl in 1984. No breakdown is possible between production of regular butyl (a copolymer of isobutylene and small quantities of isoprene) and the two halogenated butyl rubbers (chloro- and bromo-). U.S. output of all butyl rubber during the past three years probably averaged 150,000 metric tons per year. Imports of butyl have been rising, whereas exports, which are no longer reported, apparently have been falling. The net of imports over exports is estimated at 40,000 metric tons per year, suggesting U.S. consumption approaches 200,000 metric tons per year.

IISRP estimates world capacity to make butyl rubber at 690,000 metric tons, with 110,000 metric tons of the total located in communist countries. Exxon Chemical has more than 200,000 metric tons of annual capacity in the U.S. for all forms of butyl, and Polysar has 120,000 metric tons of capacity in Canada.

About 75% of U.S. consumption of butyl rubber goes into tires, mostly as inner liners for tubeless tires and tubes. Mechanical goods and sealants take most of the remainder. Prospects for growth in butyl rubber use, therefore, depend on tire demand and size, as they do for SBR and polybutadiene. As a result, growth in butyl rubber is expected to be slow but steady.

For many types of synthetic rubber, stiff competition comes from natural rubber. Natural rubber makes up a larger part of total rubber consumption than does any individual synthetic rubber and accounts for a little more than 39% of the noncommunist countries' total rubber supply, based on 1984 figures from IISRP. Because tire use dominates consumption with more than 71% going into tires and tire products in 1984, growth in demand for natural rubber will be slow.

No significant quantities of natural rubber are produced in the U.S. Although tiny amounts of guayule rubber are produced experimentally from this bush, which grows best in arid areas of the Southwest, almost all natural rubber consumed in the U.S. is imported. In 1985, U.S. imports of natural rubber totaled more than 789,000 metric tons, according to RMA. That represents a 1% decline from 1984—the recent historical high for natural rubber imports. Three countries—Indonesia, Malaysia, and Liberia—supply the dominant share of natural rubber consumed in the U.S.

In the U.S. apparent consumption of natural rubber in 1985 was 751,200 metric tons, according to RMA. Apparent consumption of SBR in 1985 was 838,400 tons, or about 87,000 tons more than natural. The decline in consumption of SBR has been faster than the growth in consumption of natural rubber. This suggests that the U.S. is becoming more dependent on imported natural rubber. Demand for rubber in the U.S. declined in 1985 about 6.5%, confirming the change in the position of natural rubber relative to synthetic.

Improvements in natural rubber quality and lower prices are given as the biggest reasons for increased U.S. use of natural rubber and for the general increase outside communist countries. About 20 years ago, a concept known as technically specified rubber (TSR) was developed for natural rubber. The quality of the various grades of TSR

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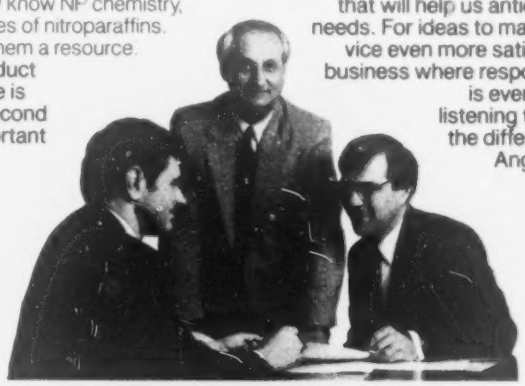

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is determined by technical specifications rather than by visual observations used in determining quality of ribbed smoked sheets (RSS), which are the next largest volume of natural rubber in world commerce. TSR has more uniformity in its composition, is cleaner than RSS, and is formed into and shipped in palletized blocks similar in size to blocks of synthetic rubber produced in most U.S. plants. TSR now dominates imports of natural rubber into the U.S., but No. 1 RSS remains the basis for reported prices. Current prices are about 42 cents per lb for No. 1 RSS delivered in New York, which is well down from more than 70 cents per lb in 1980.

Quality improvements are not limited to natural rubber. All of the synthetics have been improved vastly since their commercial production began. The demand for better quality elastomers to meet ever more stringent requirements for use in harsh environments has caused development of a host of specialty rubbers. There is no compilation of all of the specialties, because of problems of definition and of commercial significance. Considerable overlap exists among the many properties of the various specialty rubbers available commercially. The cost vs. performance factor of each specialty rubber determines whether it will be used.

The specialty rubbers are more expensive than the big-volume general-purpose rubbers. Selling prices of specialties begin at double the price of SBR and keep rising. As a result, production in the U.S. of all of the specialties probably doesn't exceed 100,000 metric tons—less than 5% of total synthetic rubber production. Two of the specialty rubbers, silicone and chlorosulfonated polyethylene, could account for half of total specialty production this year. Production data on the specialties are limited, because most of the specialties made in any quantity have very few producers.

Consumption data are even more limited. Fabricated products usually are mechanical goods such as gaskets and other automotive parts, various kinds of industrial and automotive hoses and belts, wire and cable coverings, sealants, sheet material, and myriad miscellaneous uses. Because of their properties such as high resistance to ozone, oxidation, temperature extremes, chemicals, hydrocarbons, and weathering, specialty rubbers go into these fabricated products. Considerable substitution of one specialty rubber for another occurs, however, as properties are improved and costs decrease.

The specialty rubber industry receives more attention than its size warrants, owing to its fast growth, capture of uses from nonrubber materials, and apparent high profitability. But the big-volume synthetic rubber producers also are moving ahead. In recent years, most large rubber producers have begun statistical quality and process control programs to minimize product variation and improve quality. They have done well in reducing their processing costs and in improving the quality and consistency of their products.

The higher-quality rubber produced by the big-volume synthetic rubber producers has resulted in improved quality of fabricated rubber products, and in lower costs of manufacturing. This unfortunately has reduced demand for the various types of synthetic rubber. With streamlining and development, the synthetic rubber industry in the U.S. may have become smaller, but it also has become better. □

A large fraction of the world's nitrile production is used in hoses